

SMALL TERRESTRIAL VERTEBRATE COMMUNITIES IN REMNANT VEGETATION IN THE CENTRAL WHEATBELT OF WESTERN AUSTRALIA.

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ABSTRACT

Small terrestrial vertebrate communities in the central wheatbelt of Western Australia were sampled repeatedly in nine remnants of native vegetation ranging from 10 ha to 1030 ha. Over 11,000 animals of 51 species were captured in 65,000 trapnights. The most common taxa were skinks (4,588 captures), mammals (2,348) and frogs (1,754). The most commonly caught species were *Ctenotus schomburgkii* (2,309) and *Mus domesticus* (2,062). Capture rates were low, with only four species having rates greater than 20 per 1,000 trapnights. Total species richness in the main vegetation formations (woodland, mallee, shrubland, heath) varied from 35 to 43; only 10 species were recorded in salt complex and 16 species on and around rock outcrops.

Communities in the different vegetation formations showed little similarity. Using the Bray-Curtis modification of the Sorensen index, similarity indices between formations were low (0.15 to 0.34) except for woodland/mallee (0.54) and shrubland/heath (0.74). Total species richness and lizard richness were significantly correlated with area in remnants with diverse vegetation but not in the woodland remnants alone. These studies suggest that repeated surveys may be needed in remnant vegetation to reliably document the range of terrestrial vertebrates that is present, and show further that, while large remnants may be preferred, remnants as small as 10 ha can have considerable conservation for small vertebrates if they retain diverse vegetation.

INTRODUCTION

The regional distribution of small mammals, reptiles and amphibians in the wheatbelt of

Western Australia has been well documented (Kitchener & Vicker 1981; Storr *et al.* 1981, 1983, 1986, 1990; Tyler *et al.* 1984). However,

data on individual nature reserves or remnants of native vegetation in the wheatbelt are less extensive and confined largely to the 24 reserves surveyed by the Western Australian Museum in the 1970s (Kitchener 1976). These data have been summarised by Kitchener *et al.* (1980a, & b) and Chapman & Dell (1985) in terms of the relationships between species richness and reserve area, and habitat variables and zoogeography.

Accounts of the small terrestrial vertebrate fauna at spatial scales intermediate between regional and reserve scales are lacking, yet it is at this scale that management is often aimed. The increasing awareness of the importance of privately owned remnants of native vegetation, together with attempts to reintegrate the landscape remnants for both conservation and economic values, make data of this scale important (Hobbs and Saunders 1993). This paper draws together data from a number of studies to give an overview of terrestrial vertebrate communities and their habitat use in an area of 1680 km² between Kellerberrin and Trayning in the central wheatbelt of Western Australia. It also discusses the implications of the sampling results for conservation and restoration of these communities in the future.

STUDY AREA AND METHODS

The studies were carried out in a 1680 km² area between Kellerberrin and Trayning, 200 km east of Perth, Western Australia. The

area has low relief (<100 m), with broad valleys and scattered breakaways and rock outcrops. The climate is mediterranean with hot dry summers and cool wet winters. Seasonal daily average temperatures are spring 17° C, summer 25° C, autumn 19° C and winter 12° C. Annual rainfall is 330 mm, with 50 percent falling in winter. The original vegetation was a complex mosaic of heath, shrublands and woodlands (Beard 1980), which has been cleared extensively for wheat and sheep farming. The remaining native vegetation occupies seven percent of the area, occurring in 450+ small (< 100ha) remnants and on road verges. Detailed descriptions are given by Arnold and Weeldenburg (1991), Saunders *et al.* (1993) and McArthur (1993).

During the period 1987 to 1994, 811 pitfall traps were established in eight remnants and on an extensive area of salt lakes (648 trap-nights) (Fig. 1) and were operated for a total of 65182 trap-nights. The number of trap-nights is each remnant are given in Table 4. The pitfall traps were 20 litre plastic pails (28cm diameter and 39cm deep) with a seven metre fence of flywire mesh 24cm high buried at its base, spanning the pail. The number of traps and their configuration varied between studies; 8 to 54 traps were laid out in grids with the distance between traps varying from 10 to 25 metres. Grids were established in all the major vegetation formations of the district; woodland, mallee, shrubland, heath and salt complex (natural

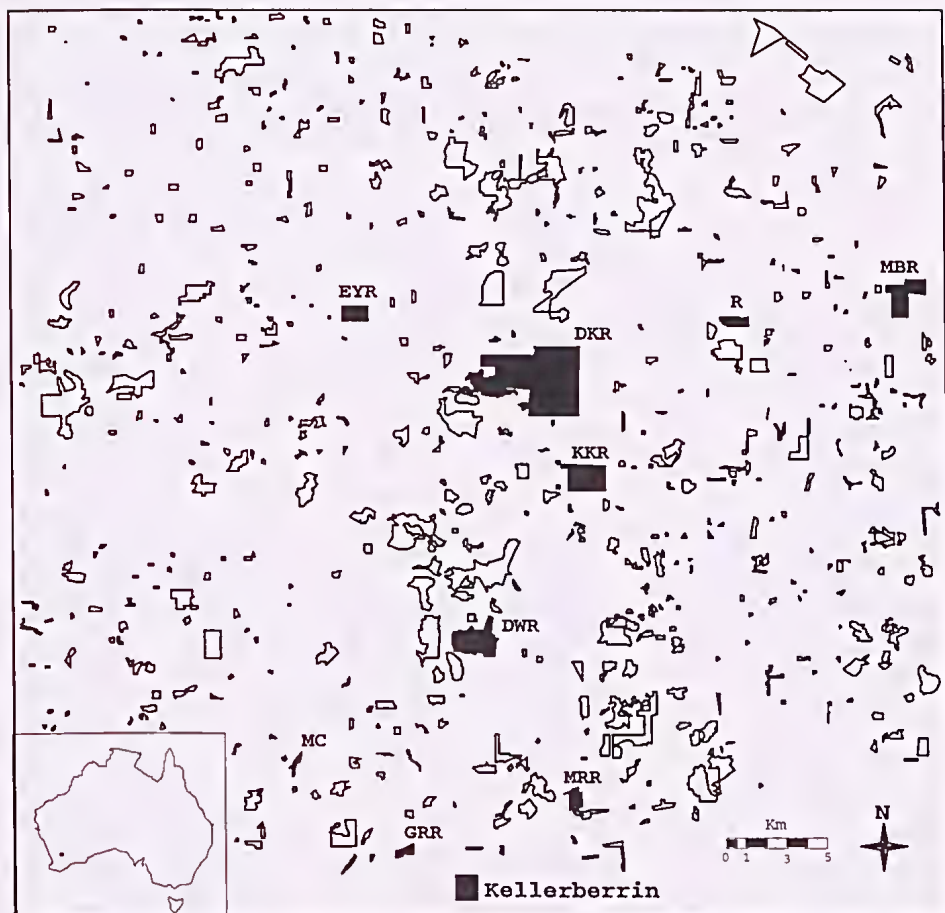


Figure 1. Map of the remnants of native vegetataion in the CSIRO study area north of Kellerberrin, showing the location of those remnants used in this study. DKR – Durokoppin Nature Reserve, NBR – North Bandee Reserve, DWR – Deep Well Reserve, EYR – East Yorkrakine Nature Reserve, R – Ryans (private land), MRR – Mooranoppin Reserve, GRR – Goldfields Road Reserve, MC – McClellands (water reserve), KKR – Kodj Kodjin Nature Reserve.

not anthropogenic). The number of trap-nights in each formation is given in Table 1. The number of trapping seasons (October to April) that each grid was operated varied from one to six. Within each trapping season, the traps were operated for four consecutive nights in October, November,

December and for two or three periods in the months of January to April. The Goldfields road reserve has a long history of grazing and the salt complex area has been grazed infrequently in recent years, the other remnants have no history of grazing. In addition, observations were made

Table 1. List of all small terrestrial vertebrates captured in the Kellerberrin-Trayning district, the number caught in pitfall traps and the number caught per 1000 trap-nights in Woodland (WL), Mallee (M), Shrubland (SL), Heath (H), Salt complex (SC) and those species observed on and around rock outcrops (L). * Observation only. Taxonomy follows STORR *et al.* 1981, 1983, 1986 and 1990; TYLER *et al.* 1994.

VERTEBRATES	TOTAL CAPTURED	No. CAPTURES / 1000 TRAP-NIGHTS					
		WL	M	SL	H	SC	L
MAMMALS							
<i>Sminthopsis crassicaudata</i>	28	0.3	0.3	0.1	0.3	15.4	
<i>Sminthopsis dolichura</i>	258	3.5	3.8	16.9	15.4	17.0	
<i>Pseudomys albocinereus</i>	*				*		
<i>Mus domesticus</i>	2062	18.3	7.1	3.0	42.7	54.0	
REPTILES							
Gekkonidae							
<i>Crenadactylus ocellatus</i>	4	<0.1	0.1	0.1	0.1	0.0	
<i>Diplodactylus granariensis</i>	154	2.3	1.6	2.7	2.6	0.0	
<i>Diplodactylus mainii</i>	233	0.1	0.0	5.5	9.3	0.0	
<i>Diplodactylus pulcher</i>	336	5.4	8.3	3.6	3.8	26.2	*
<i>Diplodactylus spinigerus</i>	44	0.1	0.1	1.4	1.3	0.0	
<i>Gehyra variegata</i>	467	17.0	1.2	0.2	0.2	12.3	*
<i>Heteronotia binoei</i>	1	<0.1	0.0*	0.0	0.0	0.0	*
<i>Oedura reticulata</i>	36	1.4	0.0	0.0	0.0	0.0	
<i>Underwoodisaurus milii</i>	*						*
Pygopodidae							
<i>Delma australis</i>	35	0.2	0.1	1.1	0.7	0.0	*
<i>Delma fraseri</i>	28	1.0	0.1	0.0*	0.0	0.0	*
<i>Delma grayii</i>	2	0.0	0.0	0.0	0.1	0.0	
<i>Lialis burtonis</i>	33	1.0	0.0	0.1	0.4	0.0	
<i>Pygopus lepidopodus</i>	5	0.0*	0.0	0.2	0.1	0.0	
Agamidae							
<i>Ctenophorus cristatus</i>	46	0.4	1.3	0.3	0.1	0.0	
<i>Ctenophorus maculatus</i>	241	0.0	0.0	6.4	9.1	0.0	
<i>Ctenophorus ornatus</i>	*						*
<i>Ctenophorus reticulatus</i>	38	0.7	2.6	0.1	0.0	0.0	*
<i>Ctenophorus salinarum</i>	13	0.0	0.0	0.0	0.0	20.1	
<i>Moloch horridus</i>	100	0.0	0.3	4.4	2.1	0.0	
<i>Pogona minor</i>	461	4.2	5.8	9.3	10.6	0.0	
Scincidae							
<i>Cryptoblepharus plagiocephalus</i>	90	3.3	0.4	0.1	0.0	0.0	
<i>Ctenotus impar</i>	5	0.0	0.0	0.1	0.2	0.0	
<i>Ctenotus pantherinus</i>	748	2.2	1.3	20.7	23.2	0.0	*
<i>Ctenotus schomburgkii</i>	2309	<0.1	1.0	50.4	96.4	0.0	
<i>Eremiascincus richardsonii</i>	1	<0.1	0.0	0.0	0.0	0.0	

Table 1 (cont.)

VERTEBRATES	TOTAL CAPTURED	No. CAPTURES / 1000 TRAP-NIGHTS						
<i>Lerista distinguenda</i>	80	0.4	0.1	2.6	1.9	0.0		
<i>Lerista macropisthopus</i>	60	2.0	0.5	0.1	0.2	1.5	*	
<i>Lerista muelleri</i>	123	2.4	2.0	1.8	0.6	12.3	*	
<i>Menetia greyii</i>	616	20.0	2.5	2.1	2.2	17.0	*	
<i>Morethia butleri</i>	1	<0.1	0.0	0.0	0.0	0.0		
<i>Morethia obscura</i>	494	0.4	1.6	15.6	15.0	0.0		
<i>Tiliqua occipitalis</i>	12	0.0*	0.3	0.5	0.2	0.0		
<i>Tiliqua rugosa</i>	48	0.9	0.7	0.9	0.9	0.0		
Varanidae								
<i>Varanus gouldii</i>	40	0.6	0.8	0.5	1.0	0.0		
<i>Varanus tristis</i>	9	0.3	0.0	0.1	0.0	0.0		
Typhlopidae								
<i>Ramphotyphlops australis</i>	8	0.5	0.1	0.1	0.0	0.0		
<i>Ramphotyphlops hamatus</i>	3	0.1	0.0	0.0	0.0	0.0	*	
<i>Ramphotyphlops waitii</i>	29	0.8	0.0	0.4	0.2	0.0		
Boidae								
<i>Morelia spilotus</i>	*		*					
Elapidae								
<i>Pseudechis australis</i>	*				*			
<i>Pseudonaja modesta</i>	2	0.0*	0.3	0.0	0.0	0.0		
<i>Pseudonaja nuchalis</i>	21	0.1	0.9	0.4	0.2	1.5	*	
<i>Rhinoplocephalus gouldii</i>	14	0.2	0.3	0.3	0.2	0.0		
<i>Vermicella bertholdi</i>	23	0.7	0.0	0.1	0.2	0.0		
<i>Vermicella semifasciata</i>	23	0.0	0.0	0.8	0.8	0.0		
FROGS								
Leptodactylidae								
<i>Heleioporus albopunctatus</i>	702	1.2	3.8	17.3	24.0	0.0		
<i>Limnodynastes dorsalis</i>	33	0.7	0.0	0.1	0.8	0.0		
<i>Myobatrachus gouldii</i>	1	0.0	0.0	0.1	0.0	0.0		
<i>Neobatrachus kunapalari</i>	498	3.7	10.2	12.2	9.0	0.0	*	
<i>Neobatrachus pelobatoides</i>	4	0.0	0.3	0.1	0.0	0.0		
<i>Pseudophryne guentheri</i>	516	2.8	2.8	16.4	11.2	0.0	*	
<i>Ranidella pseudinsignifera</i>	*						*	
TOTAL CAPTURES	11 138							
NO. TRAPNIGHTS		22,054	7,632	14,648	16,200	648	0	

on and around rock outcrops in the area, and in 24 small isolated remnants of Gimlet *Eucalyptus salubris* woodland.

RESULTS

A total of 11138 small vertebrates of 51 species were captured, comprising 2348 mammals (3 species), 1275 geckos (8 species), 103 legless lizards (5 species), 899 dragons (6 species), 4587 skinks (13 species), 49 monitors (2 species), 40 blind snakes (3 species), 83 snakes (5 species) and 1754 frogs (6 species). The number of captures exclude the small number of recaptures within a trapping session, but include animals that died or were killed in the traps. *Mus domesticus* occasionally killed and ate small reptiles, but usually left sufficient remains to identify the species. They were not killed to check stomach contents.

The most frequently caught species were the skink *Ctenotus schomburgkii* (2309 captures) and the introduced House Mouse *Mus domesticus* (2062). Fifteen species were captured between 100 and 1000 times, 21 species between 11 and 100 times and 13 species were captured on less than 10 occasions. A further six species were recorded only from observations (Table 1).

The number of species in each taxon that were recorded in the major vegetation formations is given in Table 2. Woodland and shrubland had the most species (43), heath and mallee had 38 and 35 species respectively, whereas only 10 species were recorded in salt complex. The small number of species recorded in salt complex is in part due to the small number of trap-nights (648 – Table 1), run in one season. However, examination of data

Table 2. Number of species in the small terrestrial vertebrate taxa recorded in Woodland (WL), Mallee (M), Shrubland (SL), Heath (H), Salt Complex (SC) and on and around rock outcrops (L).

VERTEBRATES	WL	M	SL	H	SC	L
Mammals	3	3	3	3	3	0
Geckos	8	6	6	6	2	4
Legless Lizards	4	2	4	4	0	2
Dragons	3	4	5	4	1	2
Skinks	12	10	11	10	3	4
Monitors	2	1	2	1	0	0
Blind Snakes	3	1	2	1	0	0
Snakes	4	4	4	5	1	1
Frogs	4	4	6	4	0	3
Total Lizards	29	23	28	25	6	12
Total	43	35	43	38	10	16

from pitfall traps operated in woodland and mallee at the same time, showed that two to three times as many lizard species were captured in an equivalent number of trap nights in these formations. Further, the comparison suggested that the absence of frogs may be real or that the populations are very low compared with mallee and woodland. Apart from salt complex, there were no marked variations in the number of species in the various taxa between the other vegetation formations. On rock outcrops three species of frogs were recorded breeding in pools (Table 1). The gecko *Gehyra variegata* was found on all outcrops searched, whereas the dragon *Ctenophorus ornatus* was found only on the larger outcrops. The remaining species were found under rocks on the apron of the outcrops and were the more common species, that have generalised habitat requirements.

The capture rate per 1000 trap-nights for each species in each vegetation formation is given in Table 1. The overall capture rate was 171.2 animals per 1000 trap-nights. Capture rates for legless lizards (1.6), monitors (0.8), blind snakes (0.6) and snakes (1.3) were extremely low, suggesting low populations or that pitfall traps were not an efficient method for their capture. In the case of monitors and larger snakes, only the dispersing young were captured. Capture rates for the other taxa ranged from 13.8 per 1000 trap-nights for dragons to 70.5 for skinks. Capture rates for

most individual species in the vegetation formations were low. Thirty-one percent of species had capture rates greater than one per 1000 trap-nights and only 10.5% were greater than 10/1000 trap-nights.

Nine species were recorded in all vegetation formations and a further 17 were recorded in all but the salt complex. Combined, the two groups consisted of 3 mammals (*Sminthopsis crassicaudata*, *S. dolichura*, *Mus domesticus*), 5 geckos (*Crenadactylus ocellatus*, *Diplodactylus granariensis*, *D. pulcher*, *D. spinigerus*, *Gehyra variegata*), one legless lizard (*Delma australis*), 2 dragons (*Ctenophorus cristatus*, *Pogona minor*), 9 skinks (*Ctenotus pantherinus*, *C. schomburgkii*, *Lerista distinguenda*, *L. macropisthopus*, *L. muelleri*, *Menetia greyii*, *Morethia obscura*, *Tiliqua occipitalis*, *T. rugosa*), 1 monitor (*Varanus gouldii*), 2 snakes (*Pseudonaja nuchalis*, *Rhinoplocephalus gouldii*) and 3 frogs (*Heleioporus albopunctatus*, *Neobatrachus kunapalari*, *Pseudophryne guentheri*). The percentage of species in each taxon that showed broad habitat preferences is as follows; mammals (75%), geckos (56%), legless lizards (20%), dragons (29%), skinks (69%), monitors (50%), blind snakes (0%), snakes (43%), and frogs (43%). Species with more precise habitat preferences were determined by using the capture rates for species captured more than 20 times. Species were considered to show a strong preference if the captures rate in one vegetation formation was more than twice that in any other formation. If the capture

rates in the two most commonly used formations differed by less than a factor of two and the capture rate in the second most commonly used formation was three times that in the next most commonly used formation, then the species was considered to have a strong preference for the combined vegetation formations. Six species (*Oedura reticulata*, *Delma fraseri*, *Lialis burtonis*, *Cryptoblepharus plagiocephalus*, *Ramphotyphlops waitii*, *Vermicella bertholdi*) were most commonly captured in woodlands; two (*Ctenophorus cristatus*, *Ctenophorus reticulatus*) in mallee; one, *Moloch horridus* in shrubland; none in heath; four (*Sminthopsis crassicaudata*, *Diplodactylus pulcher*, *Ctenophorus salinarum*, *Lerista muelleri*) in salt complex which has small patches of woodland. *C.salinarum* was captured only in samphire and two (*Ctenophorus ornatus*, *Ranidella pseudinsignifera*) were recorded only on rock outcrops. *Limnodynastes dorsalis* was found most commonly in woodland and heath; *Gehyra*

variegata, *Lerista macropisthopus* and *Menetia greyii* were captured most commonly in woodland and salt complex. Eleven species were found most commonly in shrubland and heath (*Diplodactylus mainii*, *D spinigerus*, *Delma australis*, *Ctenophorus maculatus*, *Ctenotus pantherinus*, *C. schomburgkii*, *Lerista distinguenda*, *Morethia obscura*, *Vermicella semifasciata*, *Heleioporus albopunctatus*, *Pseudophryne guentheri*). *Sminthopsis dolichura*, while present in all formations was captured most frequently in shrubland, heath and salt complex.

The similarity of the assemblages of species in the various vegetation formations was examined using the Sorensen index (Southwood 1978). The highest similarity was found between shrubland and heath (0.89), however, there was little difference between woodland, mallee, shrubland and heath. The index was low (0.46) for the comparison between salt complex and rock outcrop and both formations showed low similarity indices

Table 3. Values on the right of the diagonal line are the Sorensen indices for comparisons of the assemblages in the vegetation formations, those on the left are for comparisons using the Bray and Curtis modification of the Sorensen index. WL - woodland, M - mallee, SL - shrubland, H - heath, SC - salt complex, L - rock outcrop.

	WL	M	SL	H	SC	L
WL		0.85	0.84	0.79	0.34	0.47
M	0.54		0.82	0.74	0.40	0.51
SL	0.23	0.34		0.89	0.34	0.41
H	0.25	0.27	0.74		0.38	0.37
SC	0.35	0.22	0.15	0.29		0.46
L						

with the other formations (Table 3). These relationships changed markedly when abundance (capture rates) of species was taken into account in the Bray and Curtis modification (Southwood 1978) (Table 3). The high similarity between shrub-land and heath was maintained, that between woodland and mallee is reduced, whereas in all other comparisons the indices were low.

The area of the eight remnants in which the studies were carried out varied from 10 ha to 1030 ha. The numbers of species in each taxon in each remnant are shown in Table 4; data from the Western Australian Museum survey of Kodj Kodjin nature reserve (Chapman and Kitchener 1978, Dell and Chapman 1978) together

with additional observations have been included. The largest remnant (1030 ha) had 46 species while the smallest remnant (10 ha) had the second highest number of species (33). The correlation between area and number of species was significant ($r = 0.818$, $p < 0.01$). However, when the largest remnant was deleted from the set, the correlation became negative and non-significant ($r = -0.206$). The relationship between area and the number of species of lizards was similar with $r = 0.848$ reducing to 0.017 when the largest remnant was removed from the data set. Four of the remnants were predominantly woodland sites and the correlation between area and total and lizard species richness was not significant ($r = -$

Table 4. Number of species of small terrestrial vertebrates of various taxa in the study remnants in the Kellerberrin-Trayning district. Numbers in parenthesis are from surveys carried out by the Western Australian Museum. DKR – Durokoppin Nature Reserve, NBR – North Bandee Reserve, DWR – Deep Well Reserve, EYR – East Yorkrakine Reserve, R – Ryans, MRR – Mooranoppin Reserve, GRR – Goldfields Road Reserve, MC – McClellands – KKR – Kodj Kodjin Reserve (observational records for eight species have been added to Museum list for KKR)

VERTEBRATES	DKR	KKR	NBR	DWR	EYR	R	MRR	GRR	MC
Mammals	4 (3)	(2)	3	3	3 (2)	2	3	3	3
Geckos	7 (9)	(5)	4	3	5 (4)	5	5	3	6
Legless Lizards	4 (4)	(1)	1	3	3 (2)	0	3	2	2
Dragons	6 (5)	(3)	2	1	4 (3)	3	2	2	2
Skinks	11 (8)	(9)	6	7	8 (6)	5	5	4	9
Monitors	2 (0)	(1)	1	1	1 (0)	2	0	2	1
Blind Snakes	1 (0)	(0)	1	2	1 (0)	0	2	1	2
Snakes	5 (3)	(2)	2	2	4 (0)	2	1	2	3
Frogs	6 (2)	(3)	2	3	3 (1)	2	4	2	5
Total	46 (34)	26	22	25	32 (18)	22	25	21	33
Area (ha)	1030	204	174	118	80	50	40	27	10
# Trap nights	23252	–	3190	6408	11184	3308	6408	6408	4376

0.004 (NS) and 0.208 (NS) respectively). The other four remnants had diverse vegetation, ranging from woodland to heath and the comparable r values were 0.843 ($p < 0.05$) and 0.941 ($p < 0.01$). The latter result was strongly influenced by the results from Durokoppin. However, the large number of trap-nights in this remnant probably did not influence the result. In one set of pitfall trap grids operated for six years (2960 trapnights/year), 31 of the 36 species were caught in the first year. Comparable increases with further trapping in the other remnants would not significantly change the correlation. Further, species accumulation curves for the other remnants indicated that they were at or close to the asymptote and that few additional species would be expected to be captured.

DISCUSSION

This study has drawn together data from a number of studies over the last decade. One factor that the long term studies have shown is that the number of individuals and species captured is highly variable on time scales varying from days to years. Thus, combining the results of studies undertaken at different times restricts the types of analyses that can be undertaken. However, given the large body of data, the broad conclusions developed below should be reasonably robust.

The Western Australian Museum's surveys of wheatbelt reserves (Chapman and Kitchener

1978, Dell and Chapman 1978, Kitchener and Chapman 1980, Chapman and Dell 1980) included three within the study area, namely Durokoppin, East Yorkrakine and Kodj Kodjin reserves (Table 4), the first two were used in this study. The present study recorded an additional 15 species in Durokoppin and 14 species in East Yorkrakine, an indication of the value of long-term sampling and the use of pitfall traps. The majority of these additional species were captured infrequently or were seasonally active (frogs and *Moloch horridus*). The only moderately common species not recorded was *Diplodactylus pulcher* in East Yorkrakine, where it was captured frequently during our studies. The museum survey recorded four species not found in these reserves in the present study, *Crenadactylus ocellatus* in East Yorkrakine and *Heteronotia binoei*, *Underwoodisaurus milii* and *Delma fraseri* in Durokoppin. The first three species had total captures ranging from one to four in the combined studies. It is not known if these species are still on the reserve. The status of *D. fraseri* in Durokoppin is uncertain. Although only 28 captures were made of this species in all studies, its absence from Durokoppin suggests inadequate sampling in its preferred woodland habitat, rather than absence. These results indicate that in remnant vegetation, repeated surveys, carried out over long periods may be needed to obtain a reasonably complete picture of the range of vertebrate species that is present.

A total of 57 species was recorded in the district, 46 of which were found on Durokoppin. To obtain the full assemblage, data from a minimum of seven reserves had to be used. Similarly, the three reserves surveyed by the museum recorded only 36 species, but the inclusion of data from two adjacent reserves (Yorkrakine Rock; Kitchener and Chapman 1980, Chapman and Dell 1980, and Billyacatting Hill, Chapman and Kitchener 1981, Dell and Chapman 1981) provided the same list of 57 species. Clearly, even relatively large reserves with diverse vegetation such as Durokoppin will not support all species in a district. To provide an adequate catalogue of the species present, a number of reserves need to be surveyed to ensure sampling of all microhabitats and to allow for wide variations in population densities. Distributional data (Chapman and Dell 1985) indicate that only four species that could be expected to occur in the district (*Ramphotyphlops pinguis*, *Aspidites ramsayi*, *Morelia stimsoni*, *Vermicella bimaculata*) may be absent, and *A. ramsayi* may in fact be extinct in the wheatbelt (Smith 1985).

Habitat data suggest that the majority of species can occur in a variety of vegetation types. However, 43% of species with more than 20 captures, showed a strong association with one vegetation formation and a further 46% showed a similar association with two formations. The latter group was dominated by 11 species associated with shrubland and heath, which show

a number of structural and floristic similarities and in some areas are intermixed on a small scale. To some extent, the apparently broad range of habitats used, arises from the small scale mosaic of vegetation formations in the areas sampled and the high probability of species moving out of their preferred habitat at some stage in their life cycle, (e.g. the only *Ctenophorus cristatus* captured in shrubland and heath were dispersing juveniles). The conclusion that most species have a tighter habitat preference than the simple presence or absence data would suggest, is supported by the comparison of the Sorenson index from presence/absence data with that from the Bray and Curtis modification, which gives a low similarity rating to all comparisons between vegetation formations except that between shrubland and heath. Habitat data for reptiles and frogs given by Chapman and Dell (1985) provide a comparable picture, both in the number of vegetation formations used and the degree of association. The minor differences in the recorded habitat use between the two studies are most likely to be a result of the differences in the methods used, pitfall trapping versus observation and searching.

Area is an important variable in determining species richness in remnants (Kitchener *et al.* 1980a, 1980b; Kitchener and How 1982, How and Dell 1994, Smith *et al.* 1996). In the small sample of remnants in this study, area also was significantly correlated with

total species richness and with lizard richness. However, the correlations between total species and lizards and area were strongly influenced by the data from the largest and smallest remnants, as illustrated by the lack of a significant correlation when Durokoppin was dropped from the analysis. Durokoppin Nature Reserve had the largest number of total species and lizards, whereas the small (10 ha) McClellands remnant, had the second highest total number of species and the third highest number of lizards. The reason for the high species richness in McClellands is uncertain, but is probably related to diversity of vegetation (14 associations ranging from heath to woodland, GTS unpublished data) which was in good condition and ungrazed. The fifth largest reserve (East Yorkrakine nature reserve – 80 ha) had a comparable diversity of vegetation and was in good condition and ungrazed. It had the second largest number of lizards and the third highest total of species. The four remnants with diverse vegetation ranging from heath to woodlands (Durokoppin NR, East Yorkrakine NR, Ryans and McClellands) had significant correlations between total species and lizard richness and area, a result that probably was not strongly influenced by the differences in trapping effort. In contrast, the four remnants that were dominated by woodlands had no significant correlation between area and measures of species richness. These results support the findings of Kitchener *et al.* (1980a & b) that various

measures of habitat diversity are important variables in determining species richness and may be more important than area for species with low spatial requirements.

Despite the fact that 93% of the district has been cleared for at least 50 years, there is no evidence that any species of reptiles or amphibians, with the exception of *A. ramsayi*, have become extinct in the district. Species have been lost in individual remnants of woodland, especially those that are small, isolated and grazed (Smith *et al.* 1996). Capture rates suggest that the populations of some species may be very low and hence prone to extinction. *Eremiascincus richardsoni* and *Myobatrachus gouldii*, for example were captured only once despite extensive trapping over a number of years in the sites. However, we have no data to indicate whether low trapping rates are due to low population or low trapping efficiency for most species. However, *M. gouldii* is readily trapped in pitfall traps in other areas (Arnold *et al.* 1991). Studies on *Oedura reticulata* by Sarre *et al.* (1995) and Sarre (1995) indicate that small populations of species with poor dispersal abilities in small remnants are highly vulnerable to extinction from stochastic processes. Whereas the remnants in this study were considerably larger than those in the *O. reticulata* study, species with small populations may still be vulnerable to stochastic extinctions in the long-term.

Conservation of the small vertebrate fauna in the district

will depend on maintaining an adequate number of remnants in good condition and minimising disturbance from grazing and/or weed invasion. While larger remnants may be preferred, small remnants with diverse vegetation can be important in providing 'hot spots' for particular areas. While Kitchener *et al.* (1980a), suggested a minimum size of 30 ha, this study shows that remnants of the order of 10 ha may have considerable value. Remnants of this size and even smaller may play an important role in the increasing trend to rehabilitate landscapes in agricultural regions (Smith *et al.* 1996).

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